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Alteration of Perceived Fragrance of Essential Oils in Relation to Type of Work: a Simple Screening Test for Efficacy of Aroma

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Abstract

The perceptional change of fragrance of essential oils is described in relation to type of work, i.e. mental work, physical work and hearing environmental (natural) sounds. The essential oils examined in this study were ylang ylang, orange, geranium, cypress, bergamot, spearmint and juniper. In evaluating change in perception of a given aroma, a sensory test was employed in which the perception of fragrance was assessed by 13 contrasting pairs of adjectives. Scores were recorded after inhaling a fragrance before and after each type of work, and the statistical significance of the change of score for 13 impression descriptors was examined by Student's *t*-test for each type of work. It was confirmed that inhalation of essential oil caused a different subjective perception of fragrance depending on the type of work. For example, inhalation of cypress after physical work produced a much more favorable impression than before work, in contrast to orange, which produced an unfavorable impression after physical work when compared with that before work. For mental work, inhalation of juniper seemed to create a favorable impression after work, whereas geranium and orange both produced an unfavorable impression then. From these studies, together with those conducted previously with lavender, rosemary, linalool, peppermint, marjoram, cardamom, sandalwood, basil and lime, we thus concluded that the sensory test described here might serve not only as a screening test for efficacy of aroma but also as a categorized table for aroma samples which can act as a reference to each other.

Introduction

It is known empirically that inhalation of essential oils causes physiological and psychological changes in humans (Tisserand, 1977). In order to elucidate such changes, a sensory evaluation test, being a measure of consciousness developed by experimental psychology and mathematical psychology (Stevens, 1951; Guilford, 1954; Torgerson, 1958; Coombs, 1964; Kling and Riggs, 1972), is the basis not only for evaluating olfactory response to a given aroma but also for assessing changes in perception of fragrance of essential oil, both from the standpoint of semantics.

By means of a sensory test in which the perceived fragrance of essential oils was described by 13 contrasting pairs of adjectives, the sensory profiling data obtained in our previous studies (Sugawara *et al.*, 1998a, 1998b) showed that inhalation of essential oil produces a different subjective perception of fragrance before and after work depending on the type of work, using the Kraepelin mental performance test (mental work), stepping up and down (physical work) and hearing environmental (natural) sounds. For example, inhalation of linalool after hearing environmental sounds seemed to give a much more favorable impression than that before work, which is in contrast to the results for mental work and physical work (Sugawara *et al.*, 1998a). However, a large standard deviation against a smaller value of the mean for both perception scores before and after work was also observed in each essential oil to any type of work examined, and this makes it difficult to assess the perceptional changes statistically.

We were able to statistically examine the perceptional changes of a given aroma (Sugawara *et al.*, 1998b) for which the perceptional difference before and after work was obtained and examined by Student's *t*-test for 13 impression descriptors. The statistical significance of the perceptional change of a fragrance in relation to the type of work was then evaluated by a sign test, using the number of impression descriptors regarded to be significant by *t*-test, in terms of 'total significance score' and 'sensory evaluation spectrum'. Here, 'total significance score' corresponds to the number of impression items regarded to be significant by *t*-test ($P < 0.05$) among the 13 descriptors, while 'sensory evaluation spectrum' is a bar graph in which the mean of perception difference recorded before and after each type

of work for the descriptors was plotted against each descriptor.

In the present study, sensory profiling was applied to seven essential oils: ylang ylang, orange, geranium, cypress, bergamot, spearmint and juniper. These profiles, combined with those of lavender, rosemary, linalool, peppermint, marjoram, cardamom, sandalwood, basil and lime in our previous report (Sugawara *et al.*, 1998b), provide a strong basis from which to examine whether or not the sensory test described here might serve not only as a simple screening test for efficacy of aroma but also as a categorized table for aroma samples which can act as a reference to each other when examining the relationship between mood change of odor and its physiological effects.

Materials and methods

Chemicals

The essential oils of ylang ylang, orange, geranium, cypress, bergamot, spearmint and juniper were products of Fleur (London, UK). To identify the best concentration of each essential oil for inhalation experiments, a preliminary sensory test was performed with serially diluted solutions of 1/1, 1/10, 1/100, 1/1,000, 1/10,000 and 1/100,000 oil to diethyl phthalate used in an inhaler (300 ml volume) which was loaded and moistened by applying 20 μl of the diluted oil solution on a tiny strip of filter paper. The 1/10 dilution for each essential oil was used in the subsequent study, as this was the concentration deemed to be 'comfortable' by several judges.

Sensory test

The subjects were healthy 20- to 26-year-old adults. A sensory test was carried out before and after work with the inhaler according to the specifications detailed in our previous study (Sugawara *et al.*, 1998b), when the Kraepelin mental performance test (mental work), stepping up and down (physical work) and hearing environmental sounds were employed as types of work.

Mental work used the Uchida–Kraepelin mental work test consisting of numbers as a line in a row (100 numbers per row) and addition of neighboring numbers were repeated side by side. Each row was worked on for 40 s before changing to the next row, for a total of 5 min, which was followed by a 1 min rest and then another 5 min of work. Physical work was assigned to subjects stepping up and down a 20 cm step at a rate of 30 times per min for 5 min with a break of 1 min, followed by an additional 5 min of exercise. The listening activity was performed while sitting on a chair and listening to natural sounds such as bird songs or the murmuring of a small stream from a CD played for a total of 10 min with a 1 min break.

Statistics

As aroma perception was evaluated by 13 impression descriptors consisting of contrasting pairs of adjectives and scored on an 11-point scale (–5 to +5), the difference in score of impression descriptors each recorded before and after work was obtained and the statistical significance of the difference for each descriptor was evaluated by Student's *t*-test. All statistical data were calculated with a Power Macintosh 8100/100AV personal computer. The statistical significance of each impression descriptor was then scored as follows: (i) significance score = 1, if the impression difference is regarded to be significant with $P < 0.05$; (ii) significance score = 0.5, if regarded to be significant with $0.05 \leq P < 0.1$; and (iii) significance score = 0, if regarded to be insignificant with $P \geq 0.1$, where P is the level of significance.

The addition of these scores provided the following score for total significance:

$$\text{Total significance score} = \sum_{i=1}^{13} (\text{significance score of descriptor}) \, i$$

The value of this total significance score was then statistically evaluated by sign test with $n = 13$, since 13 pairs of impression descriptors were used in our sensory test. Accordingly, by using the total significance score, we could statistically evaluate the change in perception of fragrance before and after each type of work.

Results

Sensory profiling for fragrance of essential oils in relation to type of work

In our sensory profiling, a sensory test was conducted before and after mental work, physical work and hearing environmental sounds. Thirteen contrasting pairs of impression descriptors were used for the evaluation and each was scored on an 11-point scale (–5 to +5). Figure 1 shows a typical mean-deviation profile for such an experiment in fragrance when the values of mean and standard deviation of these scores each obtained before and after work for the 13 descriptors are plotted against the respective descriptors. As shown in the figure, a large standard deviation value against a smaller value of the mean for both scores of impression before and after work was observed, which led us to conclude that the statistical difference between the impression scores before and after work is negligible. This feature is notable not only for cypress in relation to physical work but also for essential oils examined in this study in relation to all three types of work.

In our statistical formalities (Sugawara *et al.*, 1998b), therefore, the score for each recorded before work was subtracted from that after work and then the statistical significance of the difference of each impression descriptor was subjected to Student's *t*-test. The resulting data for cypress with physical work are summarized in Table 1. Here,

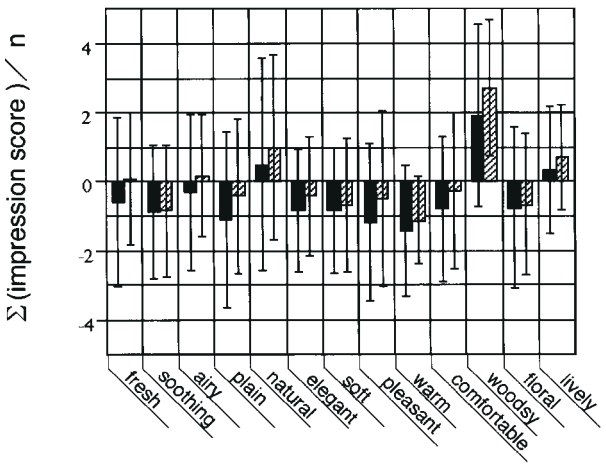

Figure 1 Mean-deviation profile for the sensory test on fragrance. The mean ± SE of each score recorded before (■) and after (▨) work for 13 impression descriptors is plotted against each descriptor as a bar graph. This graph is for cypress in relation to physical work. The number of subjects was 24.

Table 1 Student's *t*-test results for cypress in relation to physical work

Descriptor	Average difference	*t*-test significance
Fresh	0.667	0.06*
Soothing	0.042	0.93
Airy	0.458	0.28
Plain	0.667	0.05*
Natural	0.500	0.07*
Elegant	0.417	0.21
Soft	0.167	0.61
Pleasant	0.667	0.02**
Warm	0.292	0.36
Comfortable	0.542	0.06*
Woodsy	0.792	0.06*
Floral	0.083	0.57
Lively	0.375	0.22

The score for each of 13 impression descriptors was recorded before and after work and the difference was obtained. The statistical significance of the difference of each descriptor was tested by Student's *t*-test. Each item was marked with ** or * as follows : (i) marked with ** if the perception difference is regarded to be significant with $P < 0.05$; (ii) marked with * if regarded to be significant with $0.05 \geq P < 0.1$; and (iii) unmarked if regarded as insignificant with $P \geq 0.1$, where P is the level of significance.

the statistical significance by *t*-test was scored and marked as detailed under Statistics. The total significance score was also determined. This corresponds to the number of impression descriptors regarded to be significant by *t*-test with the level of $P < 0.05$ among the 13 descriptors. From Table 1, for example, the value of the total significance score for cypress in relation to physical work was calculated to be 3.5. On the other hand, the total significance score for cypress with other types of work was calculated to be 0.5

Table 2 Total significance score resulting from statistical analysis of perception of fragrance of essential oils in relation to type of work

	Physical work	Mental work	Hearing sounds
Ylang ylang	0	2	5.5
Orange	6	5	1
Geranium	1.5	5.5	2
Cypress	3.5	0.5	1
Bergamot	4	2	2.5
Spearmint	1	4.5	3
Juniper	1.5	6.5	6.5
Lavender[a]	1	0	1.5
Rosemary[a]	0	1	0.5
Linalool[a]	1	5.5	5
Peppermint[a]	2	6	3.5
Marjoram[a]	1	2	0.5
Cardamom[a]	0.5	0	3.5
Sandalwood[a]	1.5	2.5	6.5
Basil[a]	1	5	2
Lime[a]	1.5	6	1

Physical work, mental work and hearing natural sounds were employed as type of work. The number of subjects was 18–30.

[a]Taken from Sugawara *et al.* (1998b).

for mental work and 1 for hearing environmental sounds. From the values obtained for cypress, ylang ylang, orange, geranium, bergamot, spearmint and juniper, combined with those made previously for lavender, rosemary, linalool, peppermint, marjoram, cardamom, sandalwood, basil and lime (Sugawara *et al.*, 1998b), Table 2 summarizes the total significance scores of the essential oils examined so far in our study in relation to type of work.

In evaluating the changes in perception of fragrance in terms of total significance scores, we employed a sign test and 'sensory evaluation spectrum', which will be discussed next in greater detail.

Alteration of perceived fragrance of essential oils in terms of total significance score and sensory evaluation spectrum depending on the type of work

Since 13 pairs of impression descriptors were used for our sensory profiling, a sign test with $n = 13$ was introduced to evaluating the total significance scores. On the basis of the sign test, the value of the total significance score could be regarded to be as follows: (i) if >10, the perception difference in fragrance between before and after work can be regarded as significant; and (ii) if <3, the null hypothesis can be rejected.

As shown in Table 2, there is no sample with a total significance score >10 among the 48 cases examined in our study. On the other hand, there were 30 samples with the value <3, so the null hypothesis could be rejected. However, the other 18 samples, e.g. those of orange, cypress and bergamot for physical work and those of orange, geranium,

spearmint, juniper, linalool, peppermint, basil and lime for mental work, remain to be examined, because each was ≥3 and therefore the null hypothesis could not be rejected.

Even with the samples that had a total significance score of ≥3, the perceptional difference between before and after work was not significant statistically, although the null hypothesis could not be rejected. In view of this, an attempt was made to evaluate these samples by using the sensory evaluation spectrum (Sugawara *et al.*, 1998a, 1998b), because there should be no sample with a total significance score >10 due to the extraordinary scatter of scores mentioned earlier. The sensory evaluation spectrum is a bar graph in which the perception difference of a given aroma for the 13 impression descriptors is displayed, as shown in Figures 2 and 3. In the graphs, the mean of the difference between the scores recorded before and after work for each descriptor has been plotted against each descriptor. It should be noted that if there is any favorable correlation between fragrance of essential oil and type of work, a positive value for each descriptor is shown above the horizontal axis; a negative value will appear below the axis if there is any unfavorable correlation between fragrance and type of work. It is apparent from the graph that cypress created a favorable impression in relation to physical work (Figure 2a). On the contrary, the spectrum for orange in relation to physical work indicates an unfavorable impression, with a total significance score of 6, as shown in Figure 2b. This feature is thus the complete opposite to that for cypress in relation to physical work. In addition, statistical significance by *t*-test was scored and marked with ** or *, as for Table 1. We could thus easily calculate the total significance score even in the sensory evaluation spectrum.

Among the samples of essential oils with a total significance score of ≥3, if those with positive values for each impression descriptor shown above the horizontal axis of the sensory evaluation spectrum are selected, the correlation between fragrance of an essential oil and type of work can be regarded as favorable, as shown in Figure 2a. On the contrary, those negative values below the horizontal axis can be regarded as unfavorable, as shown in Figure 2b. It was found that the feature of the sensory evaluation spectrum for bergamot after physical work, with a total significance score of 4, is the same as that for orange after work, this being the reverse of that for cypress. Figure 3 shows such a difference in the perception of fragrance with mental work and hearing environmental sounds. For example, juniper created a favorable impression after mental work, with a total significance score of 6.5 (Figure 3a). In contrast to the case of juniper, the spectrum for geranium in relation to mental work indicates an unfavorable impression, with a total significance score of 5.5, as shown in Figure 3b. As for mental work, peppermint, lime, linalool and orange also created an unfavorable impression after work, with a total significance score of 6, 6, 5.5 and 5 respectively. Figure 3c,d

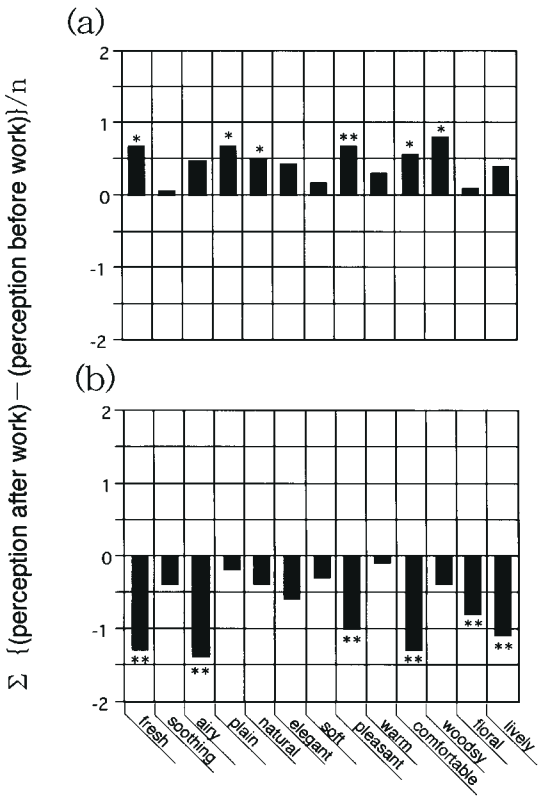

Figure 2 Bar graph (sensory evaluation spectrum) for cypress and orange in relation to physical work. **(a)** Cypress; **(b)** orange. The difference in score for each of 13 impression descriptors recorded before and after work was obtained and the statistical significance of the difference for each descriptor was tested by Student's *t*-test. The mean of the difference in score before and after work for each descriptor was then plotted against the 13 descriptors. Statistical significance by *t*-test was scored and marked with ** or * (see Table 1). Graph (a) shows a favorable correlation between inhalation of cypress and physical work, with a total significance score of 3.5. In contrast to the case of (a), (b) shows an unfavorable correlation between inhalation of orange and physical work with a score of 6. The number of subjects was (a) 24 and (b) 27.

depicts the difference in perception of ylang ylang and cardamom in relation to hearing environmental sounds, with a total significance score of 5.5 and 3.5 respectively. As for hearing environmental sounds, juniper, sandalwood, linalool, peppermint and spearmint each left a favorable impression similiar to that of ylang ylang.

Table 3 summarizes such a difference in perception of fragrance among the samples of essential oils with a total significance score of ≥3 so far examined in our study. In the table the impression of spearmint after mental work was classified as miscellaneous in terms of its sensory evaluation spectrum: half of the items had a positive value, were regarded as being significant by *t*-test and marked with * or **, and are shown above the horizontal axis; but the other half had a negative value and are shown below the horizontal axis (Figure 4).

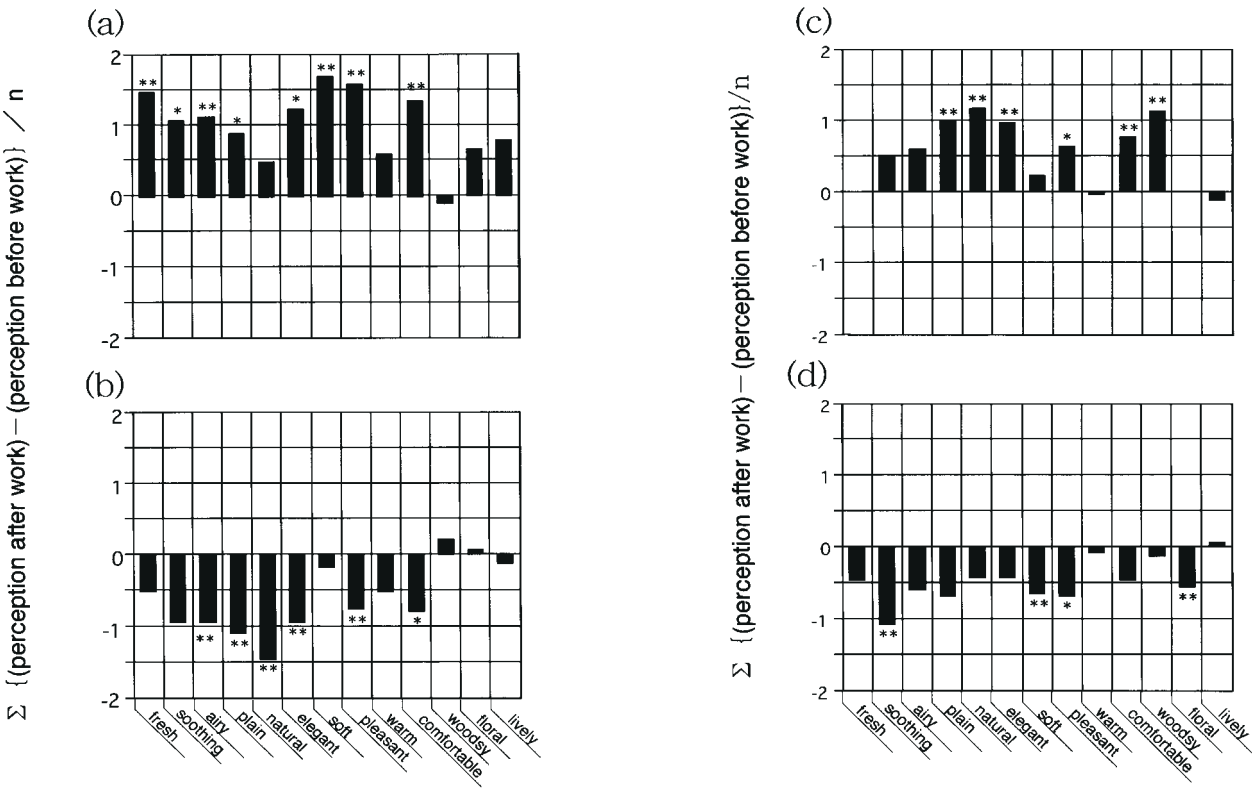

Figure 3 Sensory evaluation spectrum for mental work and hearing environmental sounds. **(a)** Juniper and **(b)** geranium for mental work, and **(c)** ylang ylang and **(d)** cardamom for hearing environmental sounds. Statistical significance by *t*-test was scored and marked with ** or * as in Table 1. As for mental work, graph (a) shows a favorable correlation between inhalation of juniper and mental work, with a total significance score of 6.5, while (b) shows an unfavorable correlation between inhalation of geranium and mental work, with a score of 5.5. Graphs (c) and (d) show a same correlation of ylang ylang versus cardamom for hearing environmental sounds, with total significance scores of (c) 5.5 and (d) 3.5. The number of subjects was (a) 17, (b) 21, (c) 24 and (d) 23.

Discussion

There are many published reports in the literature on odors being used to alter mood, alertness and sexual arousal (Billot and Wells, 1975; Valnet, 1982; Morris, 1984). Perfumes, room odorizers and incense have been used for self-adornment and modification of the living environment from ancient times. The practice of treatment known as 'aroma therapy' has developed rapidly during the last century. In spite of these naturalistic uses of odors and anecdotal accounts of their effects, little objective evidence of odor effects has been published in the scientific literature (Lorig, 1989).

Based on sensory profiling and its statistical consideration, the present study showed that inhalation of essential oil causes a different subjective perception of fragrance depending on the type of work undertaken; for example, inhalation of cypress after physical work produced a much more favorable impression than that before work, in contrast to the case of orange with physical work, which produced an unfavorable impression when compared with that before work. The feature of the sensory evaluation spectrum for bergamot after physical work is the same as

Table 3 Change in perception of fragrance of essential oils

Perception of fragrance after work	Physical work	Mental work	Hearing sounds
Up	cypress (3.5)	juniper (6.5) basil (5)[a]	juniper (6.5) sandalwood (6.5)[a] ylang ylang (5.5) linalool (5)[a] peppermint (3.5)[a] supermint (3)
Down	orange (6) bergamot (4)	peppermint (6)[a] lime (6)[a] linalool (5.5)[a] geranium (5.5) orange (5)	cardamom (3.5)[a]
Miscellaneous		spearmint (4.5)	

The influence of each essential oil was evaluated in terms of total significance score (in parentheses) and sensory evaluation spectrum in relation to type of work.

[a]Taken from Sugawara *et al.* (1998b).

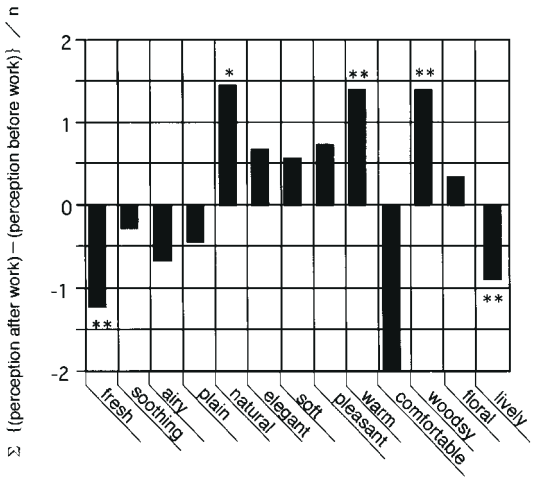

Figure 4 Sensory evaluation spectrum for spearmint in relation to mental work. Statistical significance by *t*-test was scored and marked with ** and * as in Table 1. Spearmint was classified as miscellaneous in Table 3: half of the items had a positive value and were regarded as significant by *t*-test, are marked with * or ** and are shown above the horizontal axis, the other half having a negative value and shown below the horizontal axis. The total significance score was 4.5 and the number of subjects was 18.

that for orange after work, this being the opposite of that for cypress. Identical to cypress versus orange and cypress versus bergamot with physical work, each impression of juniper and basil after mental work is the opposite of that for peppermint, lime, linalool, geranium and orange with mental work. Linalool is also of great interest in its effect after hearing environmental sounds was just the opposite of that for linalool inhalation after mental work. In such a viewpoint, peppermint is the same as linalool as a function of hearing environmental sounds versus mental work.

Much attention has recently been directed at the role of lavender and its main constituents, linalool and linalyl acetate, including its sedative and spasmolytic effects (Buchbauer *et al.*, 1991) and the distinct depression of central nervous system activity in mice (Imaseki and Kitabatake, 1963; Atanassova-Shopova *et al.*, 1974). Thus, the resulting total significance score for linalool is interesting when compared with that of lavender. As shown in Table 2, the total significance score for linalool was 5.5 after mental work and 5 after hearing environmental sounds, in contrast to the case of lavender, which scored scored between 0 and 1.5 for all types of work.

In order to examine these alterations in humans, physiological measurement was made for linalool and lavender using portable forehead surface electroencephalography (IBVA-EEG, Psychic Lab. System) with a non-smell blank as control, which utilized three-point wave sensors on a headband equipped with a telegraphic system for recording and analyzing on a Macintosh computer with a receiver (Sugawara *et al.*, 1998b). The following aspects are important: (i) linalool inhalation after hearing environmental sounds was accompanied by a considerable decrease in beta waves when compared with that before work, both compared with a non-smell blank as control; while (ii) its inhalation after mental work resulted in an increase of beta waves with a non-smell blank as control. In contrast to linalool effect, (iii) inhalation of lavender did not show such an IBVA-EEG trend for any combination of type of work.

In spite of these resulting trends, however, it is quite difficult to achieve a full understanding of olfaction and olfactory response to a given aroma in humans. It is true that the close association between the olfactory and limbic systems, which is related to sex difference, to the generation to which the subjects belong, to olfactory memory of the aroma presented in the experiment and to the biorhythm of the subjects, should be an obstruction in such an attempt. But it may also be attributable to the lack of adequate experimental support for classification of odors.

Table 3, however, may provide us with a number of practical candidates which can act as a reference to each other when examining the relationship between mood change of odor and its physiological effects: for physical work, for instance, these are cypress versus orange and bergamot versus orange; for mental work, these are juniper and basil each versus peppermint, lime, linalool, geranium and orange; for hearing environmental sounds, juniper, sandalwood, ylang ylang, linalool, peppermint and supermint each versus cardamom; and for linalool and peppermint, mental work versus hearing environmental sounds. This point is open to future study. But a pair of these might provide a clue to break through the complexity surrounding odors and attraction.

Conclusion

Sensory profiling for the 16 essential oils so far examined in this study and in our previous study confirmed that inhalation of essential oil caused a different subjective perception of fragrance depending on type of work. When three types of work were employed, 18 cases were picked out among the 48 cases after statistical consideration because of each total significance score of ≥3, in which the null hypothesis could not be rejected. Sensory evaluation spectrum of these also revealed that: (i) inhalation of cypress after physical work produced a much more favorable impression than that before work, in contrast to orange, which produced an unfavorable impression when compared with that before work; (ii) identical to cypress versus orange with physical work, the impression of juniper and basil after mental work is the opposite of that of peppermint, lime, linalool, geranium and orange with mental work; (iii) as for hearing environmental sounds, juniper, sandalwood, ylang ylang, linalool, peppermint and spearmint each versus cardamom is identical to cypress versus orange with physical work; and (iv) spearmint with mental work was classified as miscellaneous in terms of its sensory evaluation spectrum. Thus, it can be

concluded that the sensory test described here might serve not only as a screening test for efficacy of aroma but also as a categorized table for aroma samples which can act as a reference to each other when one examines the relationship between mood change of odor and its physiological effects.

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